

AN ANNOTATED KEY TO THE *RIOXA* COMPLEX OF GENERA (DIPTERA: TEPHRITIDAE: ACANTHONEVRINI)

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Abstract

The *Rioxa* complex of Indo-Australian fruit flies is reviewed and keyed. The 14 recognised species are referred to 6 genera: *Cribroriox*a Hering (1 sp.), *Ectopomyia* Hardy (2 spp), *Hexacinia* Hendel (3 spp), *Hexamela* Zia (1 sp.), *Rioxa* Walker (6 spp) and *Sophiroides* Hendel (1 sp.). *Hexacinia punctifera* (Walker, 1861), *H. multipunctata* Malloch, 1939 and *H. flavipunctata* Hering, 1940 are placed as new synonyms of *H. stellipennis* (Walker, 1860), while *Rioxa quinque maculata* Bezzi, 1913 and *R. vittata* Zia, 1963 are placed as new synonyms of *R. parvipunctata* de Meijere, 1911, **stat. rev.** and *R. sexmaculata* (van der Wulp, 1880) is placed as a new synonym of *R. discalis* (Walker, 1861). *Acinia marginemaculata* Macquart, 1851 is excluded from *Hexacinia*. A record of *Hexacinia stellipennis* from Sumatra is regarded as an error, while those of *Rioxa lanceolata* Walker from Sri Lanka and China are regarded as misidentifications of *R. parvipunctata*. Known larval hosts are fallen logs.

Introduction

This is the third in a series of papers reviewing and keying Indo-Australian and East Asian fruit flies referred to the *Acanthonevra* group in tribe Acanthonevrini (*sensu* Korneyev 1999) of subfamily Phytalmiinae. It deals with the *Rioxa* complex, which occurs from Sri Lanka and India eastwards to the Philippines and Papua New Guinea. Previous papers dealt respectively with the *Acanthonevra* and *Sophira* complexes (Hancock 2011, 2012).

Korneyev (1999) placed *Rioxa* Walker, *Ectopomyia* Hardy and *Hexacinia* Hendel in an apparently monophyletic clade within his *Acanthonevra* subgroup in the *Acanthonevra* group of genera. *Hexamela* Zia was regarded as a close ally of *Hexacinia* by Zia (1963) and Wang (1998). *Cribroriox*a Hering was included in this complex by Hancock (2005) and *Sophiroides* Hendel also appears to belong here (Hancock 2012).

All available biological information is recorded under the [incorrect] name '*Rioxa sexmaculata*'. Hardy (1986) collected specimens of [*R. parvipunctata* de Meijere] 'in mating flight around buttress of a large forest tree in botanical garden' in Bogor, Java and suspected that they might breed in rotting wood. This was confirmed by Kovac *et al.* (2010), who recorded oviposition in holes made by bark beetles or other insects in recently fallen trees in northern Thailand. Permkam (1995) collected individual specimens of [*R. discalis* (Walker)] (Fig. 1) attracted to cut shoots of the bamboos *Thyrostachys oliveri* and *Bambusa arundinacea* on three separate occasions in southern Thailand, suggesting that a casual relationship with bamboo also exists.

An annotated key to the 6 genera and 14 species recognised in this study is provided below, with several other taxa previously included in *Hexacinia* or *Rioxa* here synonymised or excluded (see Discussion). Illustrations of most species may be found in Hardy (1973, 1974, 1986) and Wang (1998).

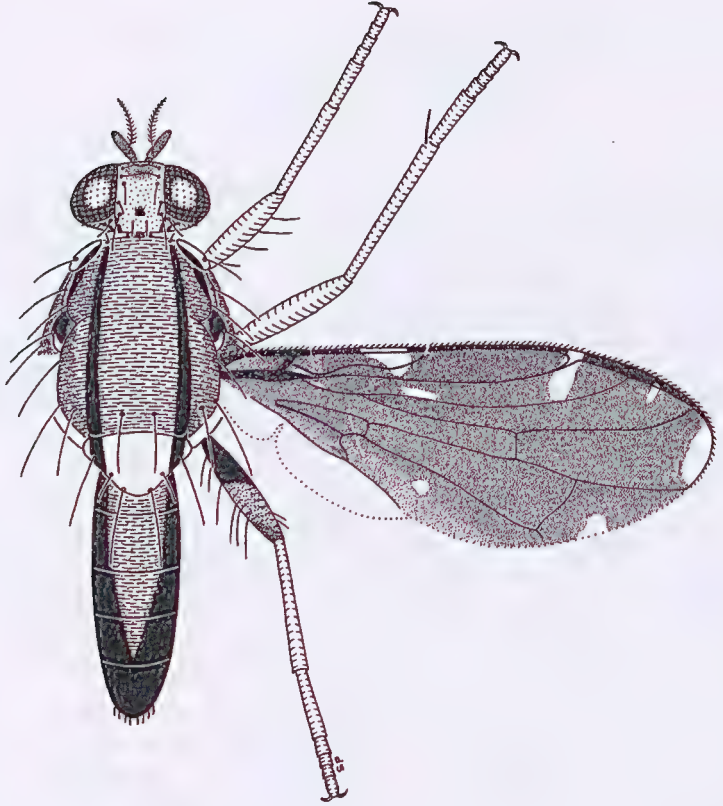


Fig. 1. *Rioxa discalis* (Walker): male from West Malaysia.

Key to genera and species

* = New distribution records based on material in The Natural History Museum, London (BMNH).

- 1 Wing pattern largely brown, yellowish basally almost to apex of cell c and with a faint brown transverse band medially, with a transverse posterior yellow indentation from wing margin across cells cu_1 and dm into cell br and with a narrow yellow transverse band from cell r_1 near apex of stigma into cell dm between R-M and DM-Cu crossveins that is broadly produced as a 2-pronged marking into subapical parts of cells r_{2+3} and r_{4+5} ; a shallow hyaline indentation in cell m along wing margin; scutum yellow with 4 dark longitudinal vittae, the dorsocentral pair not extending onto scutellum; face concave in profile; presutural setae absent; secondary scutellar setae weak and hair-like [Sri Lanka; *Rioxa magnifica* Senior-White, 1921 is a synonym; illustrated by Hardy 1968]
 *Sophiroides flammosus* Hendel, 1914

- Not as above; wing pattern blackish brown with hyaline or subhyaline spots and indentations 2
- 2 Scutum pale medially with a pair of dark dorsocentral vittae extending over sides of scutellum; pleura normally with dark vittae but not distinctly spotted; wing with vein Sc distinctly arcuate and cell m with a narrow marginal band or single small hyaline indentation; head with upper frontal setae often not close to lower setae and not reclinate; anepisternum without an additional dark seta near ventral margin centrally 3
- Scutum largely yellow with or without dark spots or dark medially with pale submedial vittae extending most of its length; pleura yellow or with brown to black spots; wing with vein Sc not distinctly arcuate and cell m with 1 large or 2 small hyaline indentations; head with upper frontal setae very close to lower setae and reclinate; anepisternum with or without an additional dark seta near ventral margin centrally 9
- 3 Wing with numerous subhyaline discal spots but no distinct hyaline marginal indentations, at most small hyaline spots towards apex of cell r_1 and over apices of veins R_{2+3} and R_{4+5} and a narrow marginal band in cells m and cu_1 ; cell c apically blunt; head setae mostly yellow [eastern Indonesia (Sumba)] *Cribrorioxia perforata* Hering, 1952
- Wing without numerous discal spots but with distinct hyaline indentations in cells r_{2+3} , r_{4+5} and m, that in cell r_{4+5} oval and almost filling apex; cell c apically acute; almost all head setae brown to black [*Ptilonina* Enderlein, 1911 is a synonym] *Rioxia* Walker, 1856 ... 4
- 4 Wing veins R_1 and R_{2+3} approximate at apex, with vein R_{2+3} less than 1/4 distance between veins R_1 and R_{4+5} ; cell r_{4+5} with a large hyaline basal spot that is more than half width of cell; cell dm often with a small subapical hyaline spot; either cell br with a broad hyaline streak or cell cu_1 with an isolated anteromedial spot 5
- Wing vein R_{2+3} more than 1/3rd distance between veins R_1 and R_{4+5} ; cell dm entirely dark, cell br with at most a faint narrow streak and cell r_{4+5} normally with at most a tiny basal spot (large in most *megispilota*) 6
- 5 Wing cell br with a broad and elongate hyaline streak extending almost to R-M crossvein [Malaysia (West, Sarawak), Singapore and Indonesia (Sumatra, Nias, Java); *R. nox* Rondani, 1875 is a synonym; records from Sri Lanka and China are errors] *R. lanceolata* Walker, 1856
- Wing cell br without an elongate hyaline streak; cell cu_1 with an isolated anteromedial spot alongside vein Cu_1 [East Malaysia (Sarawak) and Indonesia (Kalimantan: Babidjoelan*)] *R. erebus* Rondani, 1875
- 6 Wing without a distinct hyaline indentation in cell c; cell r_1 with hyaline spot near base absent and indentation at apex of cell sc absent or small and not crossing cell; cell br sometimes with a narrow and indistinct pale

- streak and base of cell r_{4+5} sometimes with a small spot [India, Sri Lanka, Burma, China (Yunnan), Thailand, Philippines (Palawan, Balabac), Malaysia (West, Sarawak) and Indonesia (Sumatra, Java, Kalimantan: Babidjoelan*); *R. quinque maculata* Bezzi, 1913, **syn. n.**, *R. infirma* Hering, 1941, *R. vittata* Zia, 1963, **syn. n.** and '*R. sexmaculata*' of Hardy (1986) are regarded as synonyms] *R. parvipunctata* de Meijere, 1911, **stat. rev.**
- Wing with distinct hyaline spots or indentations in cells c-sc and in cell r_1 near base and at apex of cell sc, the latter crossing cell 7
- 7 Wing cell cu_1 with at most an elongate, non-quadrate hyaline indentation at apex of vein A_1+Cu_2 [Burma, China (Yunnan), Thailand, Malaysia (West, Sarawak, Sabah*), Singapore* and Indonesia (Sumatra, Java); *Ptilona sexmaculata* van der Wulp, 1880, **syn. n.** and *R. sumatrana* Enderlein, 1911 are synonyms; Fig. 1] *R. discalis* (Walker, 1861)
- Wing cell cu_1 with a large quadrate hyaline indentation at apex of vein A_1+Cu_2 that crosses the cell 8
- 8 Wing with a large hyaline indentation in cell r_{2+3} below apex of vein R_{2+3} and with (females and some males) or without a large hyaline spot at base of cell r_{4+5} near R-M crossvein [southern Philippines (Tawi Tawi, Mindanao); illustrated by Hardy (1970)] *R. megispilota* Hardy, 1970
- Wing with at most a small hyaline indentation in cell r_{2+3} below apex of vein R_{2+3} and without a large hyaline spot at base of cell r_{4+5} [Philippines (including Mindanao and Tawi Tawi but not Palawan or Balabac); illustrated by Hering (1941)] *R. lucifer* Hering, 1941
- 9 Wing base largely hyaline; apex of cell r_{4+5} entirely dark; cell r_1 with a large quadrate indentation crossing cell; 2 large discal spots either side of R-M crossvein; single elongate hyaline indentations in cells m and cu_1 , the latter crossing cell; anepisternum without an additional seta; arista long plumose [China (Yunnan)] *Hexamela bipunctata* Zia, 1963
- Wing base largely dark; apex of cell r_{4+5} largely hyaline or subhyaline, discal spots normally small and subhyaline; cells m and cu_1 usually with 2 and 3 small marginal hyaline indentations respectively (combined and large in *Ectopomyia* males); anepisternum often with an additional dark seta near ventral margin centrally; arista short plumose 10
- 10 Almost all head setae brown to black; abdomen largely dark but without distinct dark spots; scutum mostly dark (including medially) with pale submedial vittae and a distinct yellow patch between prescutellar setae; scutellum yellow with a pair of submedial dark vittae; wing with apical hyaline indentations in cells r_{2+3} and r_{4+5} large and broadly ovate or subquadrate and with few discal spots; anepisternum with additional seta weak or absent *Ectopomyia* Hardy, 1973 ... 11

- Head setae mostly yellow; abdomen yellow with distinct brown to black spots; scutum and scutellum yellow with or without small dark spots; wing with apical hyaline indentation in cells r_{2+3} small and rounded and that in cell r_{4+5} subquadrate or narrowly hyaline or subhyaline and with numerous hyaline or subhyaline discal spots; anepisternum with additional seta prominent *Hexacinia* Hendel, 1914 ... 12
- 11 Wing veins R_{2+3} and R_{4+5} diverging apically, with the apex of vein R_{2+3} about equidistant between veins R_{4+5} and M at wing margin; cell r_{2+3} with a hyaline central spot near line of R-M crossvein; anepisternum with additional seta absent; sexes dimorphic in wing pattern and male with a large ventral appendage on front femur [China (Yunnan) and Laos]
..... *E. baculigera* Hardy, 1973
- Wing veins R_{2+3} and R_{4+5} almost parallel, with the apex of vein R_{2+3} distinctly closer to vein R_{4+5} than to vein M at wing margin; cell r_{2+3} without a hyaline central spot near line of R-M crossvein; anepisternum with additional seta present; male unknown [West Malaysia; illustrated by Chua 2009] *E. hancocki* Chua, 2009
- 12 Wing cell r_{4+5} with a broad subquadrate hyaline spot at apex not filling cell; antennae brown to black on apical half [India, Sri Lanka, Burma, China (Yunnan), Thailand, Vietnam, West Malaysia, Indonesia (Sumatra) and Brunei (Chua 2002); presence in Philippines (Luzon) requires confirmation: the type locality, Manila, is possibly incorrect; *H. stellata* (Macquart, 1851) (a homonym) and *H. nigroantennata* Hering, 1956 are regarded as synonyms] *H. radiosa* (Rondani, 1868)
- Wing cell r_{4+5} narrowly subhyaline at apex; antennae entirely yellow ... 13
- 13 Wing cell r_1 with 2 hyaline to subhyaline indentations from costa, both crossing cell; discal spots large, consisting mostly of transverse, elongate spots equal or nearly equal to width of cell; scutum and pleura almost entirely pale or with only a few faint brown spots [Philippines (including Palawan)]..... *H. pellucens* Hardy, 1970
- Wing cell r_1 with 2 or 3 hyaline to subhyaline indentations from costa, the medial spot often vestigial or absent; discal spots small, generally rounded and occupying only a fraction of width of cell; scutum and pleura usually with numerous dark brown to black spots [Philippines (including Tawi Tawi but not Palawan), Brunei (Chua 2002), East Malaysia (Sabah), eastern Indonesia (Sulawesi, Maluku, West Papua) and Papua New Guinea (including Bismarck Archipelago: Hancock and Drew 2003 and Bougainville: Hardy 1986); *H. punctifera* (Walker, 1861), **syn. n.**, *H. stigmatoptera* Hendel, 1928, *H. multipunctata* Malloch, 1939, **syn. n.**, *H. flavipunctata* Hering, 1940, **syn. n.** and *H. celebensis* Hering, 1941 are regarded as synonyms; a record from Sumatra (Hardy 1986) appears to be an error] *H. stellipennis* (Walker, 1860)

Discussion

Hexacinia

Acinia marginemaculata Macquart, 1851, described from 'Asia' (Macquart 1851), was placed in *Hexacinia* by Foote (1984) and Norrbom *et al.* (1999), possibly following a suggestion by Bezzi (1913), but its narrow wing and pattern of markings, particularly the numerous (5-6) marginal spots in cell m, suggest it does not belong there. It is possibly a species of *Paracanthella* Hendel (subfamily Tephritinae) but examination of the type is needed to determine its identity and relationships.

Hexacinia palpata Hendel, 1915, from China, Taiwan and far eastern Russia, was retained in that genus by Hardy (1973, 1974) but was included in genus *Hexaptilona* Hering by Zia (1963) and Wang (1998). Together with the closely related *H. hexacinioides* (Hering, 1938) from Burma, it is currently placed in subfamily Blepharoneurinae (Norrbom and Condon 1999).

Specimens referable to both *H. stellipennis* (Walker) and *H. punctifera* (Walker) occur in Sulawesi (Hardy 1959, DLH pers. obs. of BMNH specimens), Borneo (Hardy 1986, Chua 2002) and New Britain (Hancock and Drew 2003) and the two taxa do not appear to be separable. The size of the medial spot in cell r_1 is variable and sometimes vestigial or absent (Hancock and Drew 2003), with a small spot present in the holotype of *H. celebensis* (Hering 1941). The number and intensity of the dark pleural spots also appear to be variable (Hardy 1974). Accordingly, I am treating *H. punctifera* (Walker, 1861), *H. multipunctata* Malloch, 1939 and *H. flavipunctata* Hering, 1940 as new synonyms of *H. stellipennis*, together with the previously synonymised *H. stigmatoptera* Hendel, 1928 and *H. celebensis* Hering, 1941. Whereas the male epandrium and surstyli appear to be relatively longer and more slender in *H. pellucens* Hardy [and even more so in *H. radiosa* (Rondani)] than in *H. stellipennis* and *H. punctifera*, there appear to be no discernible differences between the latter two taxa (Hardy 1974, 1986).

Hardy's (1986) record of *H. stellipennis* from Sumatra, based on specimens allegedly in BMNH, appears to be an error, since no Sumatran specimens of the genus were found there during a visit in 2012 (DLH pers. obs.).

Rioxa

There has been considerable confusion in the literature concerning the nomenclature and identity of *Rioxa sexmaculata* (van der Wulp, 1880). Originally described from Sumatra (van der Wulp 1880), it was regarded as a senior synonym of *R. sumatrana* Enderlein, 1911, also described from Sumatra (Enderlein 1911), by both de Meijere (1914) and Hardy (1974), the latter at least basing his synonymy on examination of the types. Later, however, Hardy (1986) again separated the two taxa, with *R. sumatrana* subsequently placed as a junior synonym of *R. discalis* (Walker, 1861) by Hancock (1998). Hardy (1973, 1986) regarded *R. quinquemaculata* Bezzi,

1913, as a junior synonym of *R. sexmaculata* and appears to have used the former taxon, described from Tenasserim, Burma (Bezzi 1913) as the basis for his 1986 definition of *R. sexmaculata*, incorrectly listing the 'Type ♀' of the latter as in the Zoological Museum, University of Copenhagen. However, he had previously (Hardy 1969) correctly recorded the 'Lectotype ♂' as in the Zoological Museum, University of Amsterdam, so his 1986 concept of *R. sexmaculata* (unlike that in Hardy 1974) appears not to be based upon the types. Indeed, the type series of *R. sexmaculata*, as illustrated by van der Wulp (1881), is clearly synonymous with *R. discalis* and *R. sumatrana*. The apical extension to wing cell bcu is shown incorrectly elongate in van der Wulp's figures 10 and 11 but correctly in his figure 7; the incorrect state was used by Enderlein (1911) to define his new genus *Ptilonina* and separate *R. sexmaculata* from *R. sumatrana*.

Based on Hardy's (1986) concept of *R. sexmaculata*, Hancock and Drew (1995) synonymised *R. parvipunctata* de Meijere, 1911 with it. However, the latter species, originally described from Java (de Meijere 1911) as a variety [subspecies] of *R. sexmaculata*, is recognised here as distinct, with *R. quinquemaculata* Bezzi, 1913, *R. infirma* Hering, 1941 and *R. vittata* Zia, 1963 placed as synonyms, two newly so. Hardy (1973) had previously recognised the synonymy of *R. infirma*.

Records of *R. parvipunctata* (as '*R. sexmaculata*') and *R. discalis* (as '*R. sumatrana*') from West Papua, Indonesia and Malaita, Solomon Islands respectively (Hardy 1986) were regarded as errors by Hancock and Drew (2003), the former being the result of a misinterpreted specimen label that actually refers to Soekaboemi, Java. Records of *R. lanceolata* from Sri Lanka and Yunnan, China are also errors, with both based on misidentifications of *R. parvipunctata*. Specimens recorded from Sri Lanka (Hendel 1928) lack the hyaline markings either side of the R-M crossvein, while that from Yunnan (Wang 1998) has a faint pale streak in cell br and a small basal spot in cell r₄₊₅. Similar variation in wing markings was noted from Sri Lanka by Hering (1956, as '*R. infirma*'), while Hancock and Drew (1995) also recorded a Malaysian specimen (as '*R. sexmaculata*') with a small basal spot in cell r₄₊₅.

Two additional species included in *Rioxa* by Norrbom *et al.* (1999), viz. *Trypeta manto* Osten Sacken and *Rioxa vinnula* Hardy, were transferred to *Freyomyia* Hardy, in the *Acanthonevra* complex, by Hancock (2011).

Biogeography

The *Rioxa* complex is almost entirely restricted to South and Southeast Asia, extending as far west as India and Sri Lanka but only as far north as Yunnan Province in southern China. Although well represented in the Philippines, only two species are otherwise known east of Borneo (*Cribrorioxia perforata* and *Hexacinia stellipennis*), with only *H. stellipennis* reaching the island of New Guinea and the Bismarck Archipelago.

Three monotypic genera are known, with limited and peripheral distributions: *Sophiroides* in Sri Lanka, *Cribroriox*a on Sumba in the Lesser Sunda Islands and *Hexamela* in Yunnan, China. All have relatively broad wings with an almost or entirely dark apex to cell r_{4+5} and an often weak or narrow hyaline marginal indentation in cell m. *Cribroriox*a shares with *Riox*a the distinct dark vittae over the scutum and scutellum and an arcuate vein Sc, while *Hexamela* shares with *Hexacinia* the lack of scutal vittae and the mostly yellow head setae with the upper frontals reclinate. The affinities of *Sophiroides* are uncertain but it is possibly an ancestral relict.

Hexacinia, *Ectopomyia* and *Riox*a are centred in SE Asia. Some species of *Hexacinia* and *Riox*a are widespread, with two (*H. radiosa* and *R. parvipunctata*) recorded from India and Sri Lanka to at least Borneo and one (*H. stellipennis*) known from the Philippines and Borneo to Papua New Guinea. *Riox*a *discalis* is known from Burma and Yunnan to Borneo and Java, while *Ectopomyia* has a more restricted distribution, with the two species (*E. baculigera* and *E. hancocki*) known from Yunnan-Laos and West Malaysia respectively. *Riox*a *lanceolata* is known from West Malaysia to Borneo and Java and *R. erebus* is known only from Borneo. Three species (*H. pellucens*, *R. lucifer* and *R. megispilota*) appear to be endemic to the Philippines. All three genera have a distinctly slender epandrium, surstyli and proctiger and a hyaline or subhyaline apex to cell r_{4+5} , best developed in *Riox*a, *Ectopomyia* and *Hexacinia radiosa*.

The spotted pleura, reclinate upper frontal setae and presence of 2 hyaline marginal indentations in cell m and (usually) 3 in cell cu_1 in *Ectopomyia* and *Hexacinia*, plus the presence of a weak anepisternal seta near the ventral margin centrally in *E. hancocki* and the subquadrate shape of the hyaline apical spot in cell r_{4+5} in *H. radiosa*, suggest a close (and possibly sister-group) relationship. *Riox*a differs from the other two genera in scutal and scutellar markings, in having the upper frontal setae incurved and the vanes of the phallapodeme fused into a Y-shaped structure, and from all the other genera in vein Sc reaching the costa at a distinctly acute angle.

Biology

The log-breeding biology of *Riox*a *parvipunctata* is very similar to that seen in the *Dacopsis* and *Acanthonevra* complexes (Permkam and Hancock 1995, Hancock 2013) and the relationship between them and the *Sophira* complex, which uses living bamboo (Hancock 2012), requires further investigation.

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